Production of Meat Substitutes from Spent Brewers' Yeast and Soy Protein

D. L. Gibson and B. K. Dwivedi

Department of Dairy and Food Science
University of Saskatchewan, Saskatoon

Abstract

Debittered and dried brewers' yeast, prepared by a modified alkaline wash process developed by the authors, was used as the base material for the production of meat analogs. An isolated soy protein was added to debittered brewers' yeast to increase the protein content and to improve the texture of the prepared products. The process used for the preparation of meat analogs was based on unfolding the coiled polypeptides of vegetable proteins by heat denaturation and increasing the degree of cross-linking between these polypeptides by cation bridges. This was carried out at a pH above the isoelectric point of the proteins, and the resulting product had not only a meaty texture, but also a high water absorbing capacity. As different meat products require different processing conditions, the methods were modified to suit the individual product.

A cobination of yeast and vegetable protein hydrolysates was successfully used to impart a meaty flavor.

Résumé

La levure de bière débarassée de son amertume et séchée, préparée par une modification du procédé de lavage à l'alcali développé par les auteurs, a été utilisée comme matière première à la production de simili-viandes. On a ajouté des protéines de Soja à la levure de bière pour augmenter la teneur en protéines et pour améliorer la texture des produits préparés. Le procédé qui a servi à la préparation des simili-viandes est basé sur l'élongation des polypeptides spiralés des protéines végétales par dénaturation thermique et l'augmentation du nombre de liaisons secondaires entre ces polypeptides par des ponts cationiques. Ceci a été fait à un pH au-dessus du point isoélectrique des protéines, et le produit obtenu avait non seulement une texture carnée mais aussi une capacité de retention d'eau élevée. Comme les différents produits carnés exigent des conditionnements spéciaux, les méthodes ont été modifiées pour convenir au produit particulier.

Un mélange d'hydrolysats de levure et de protéine végétale a été utilisé avec succès pour simuler le goût de viande.

Introduction

Brewers yeast has been widely recognized as an excellent source of protein and B-vitamins. However, a large portion of brewers' yeast is discharged into the sewage system as waste because of its bitter flavor and is not used appreciably in any major food. This work was undertaken to develop palatable high protein products from yeast prepared by the debittering process of Dwivedi and Gibson (1970). Since meat is one of the most attractive forms of protein foods, this study was designed to develop simulated, comminuted meat products from yeast and vegetable proteins.

Proteins are recognized as having two principal types of molecular configuration, fibrous and corpuscular. Since most of the animal proteins are fibrous in nature, much of the published research has dealt with aspects of modifying the structure of vegetable proteins by solubilization, unfolding and mechanical formation of fibres, together with orientation, in order to simulate animal proteins.

A number of processes have been described for making meat analogs. The most significant contribution in this field was made by Boyer (1954), who developed a synthetic meat product which closely resembled natural meat in appearance, flavor, fibrous quality, nutritive value and chewiness. The process involved the dispersion of vegetable protein in an alkaline solution and forcing it through a fine die into an acid salt solution. The protein was precipitated in the form of filaments and then bound together by an edible cereal or protein binder. Various types of meats were simulated by this method. Thulin and Kuramoto (1967) varied the texture from tender delicate fibres to tough strands by changing a number of variables such as the composition of the spinning solution, the conditions of precipitation and the treatment of filaments after formation.

Since vegetable proteins are soluble in aqueous media except at their isoelectric point it is necessary to spin these fibres in the vicinity of their isoelectric point. This results in poor water holding capacity and spongy structure, drastically different from the typical characteristics of meat described by Giddey (1965). Many different techniques have been proposed to improve the texture of vegetable proteins but the basic principle consists of increasing the degree of cross linking and subsequently reinforcing the network without promoting an irreversible denaturation of protein. Giddey (1965) further suggested that the formation of interchain bridges occurs by the use of bivalent ions such as calcium, and magnesium, or a combination of heat treatment with the chemical effect of proteo-reactive polysaccharides.

The process developed in this investigation is based on unfolding of peptide chains of proteins by heat denaturation and immobilizing the protein network with increased cross-linking by the formation of calcium bridges (Giddey, 1965) between free carboxylic groups of adjoining peptide linkages. Since this operation is carried out above the isoelectric point of the proteins the resulting product has a high water absorbing capacity and meaty texture.

Experimental Procedures

Debittered brewers' yeast was used as the base ingredient and combined with a number of filling and binding materials at various levels to impart cohesiveness and desired texture in each of the three following products:

a) "Meat balls." With the exception of water all ingredients were weighed individually and then blended together. A predetermined amount of water was worked in to form a dough. This was held at about 5°C for a minimum of 12 h. to allow the proteins and other basic ingredients to absorb moisture. Then the dough was allowed to remain at 20°C for

about 15 min. after which time it was formed into small balls, weighing 10 g. each. These balls were steamed for 30 min., allowed to cool for 5 min. and then deep fried in vegetable oil at 150°C for 5 min. After draining the oil for 1 min., the meat balls were placed into 8 fl. oz. cans together with hot spaghetti, and then sealed, autoclaved at 15 psi for 30 min. and cooled.

b) "Wieners." Wiener dough was prepared as described for meat balls, except for the difference in composition (Table 2). The freshly prepared dough was pumped into wiener casing, using a filling assembly attached to a Hobart mixer. Raw wieners were stored at about 5°C for a minimum period of 12 hr. and then immersed in boiling water for 1 hr. Finally, the wieners were cooled in cold water, packed in polyethylene bags and stored in a refrigerator.

c) "Hamburgers." The weighing and mixing of hamburger ingredients (Table 3) were carried out as described for meat balls. The prepared dough was stored at about 5°C for a period of 12 h. and then transferred into 8 fl. oz. cans and sealed. The filled tins were heated in boiling water for 1 hr., allowed to cool, and then opened by removing both ends. The cooled product was removed from the cans, cut into 7 mm slices, packed in moisture proof plastic bags and stored at —20°C.

Analytical Procedures

Moisture determinations were carried out by means of the 16 hr. hot air oven method as recommended by A.O.A.C. (1965). The nitrogen content was estimated by following the semi-micro Kjeldahl method as modified by Bremner (1960). Total proteins were calculated by multiplying the total nitrogen by 6.25. The ash content was measured according to the procedure outlined by A.O.A.C., (1965). Fat determinations were carried out as for fat in whole milk powder described by Mojonnier (1925).

Hardness of the finished products was measured with a Precision pentetrometer. The metal cone of 30°angle and a total weight of 150 g. was allowed to penetrate into the sample. After 5 seconds the penetration depth was recorded.

Results and Discussion

The texture of food products depends on a number of factors such as nature of proteins, carbohydrates and other constituents together with their relative proportions. In attempting to develop a meat-like texture most of the filler and binding materials except soy protein isolates were found unsatisfactory, since they tended to give a gummy or starchy cereal conistency to the products (Tables 1, 2 3). The soy protein isolates, being reaonably pure proteins, were easily modified during processing to simulate the texture of meat.

Processing conditions were the major factors in determining the final texture of the simulated products. It was necessary to store the meat ball and hamburger dough at 5°C for about 12 h. to allow the ingredients to absorb moisture before further processing. Wiener dough, after 12 h. storage, was difficult to pump into wiener casing and, therefore, was cased first and then held for 12 h. at 5°C. It was observed that the texture of meat balls was greatly improved by steaming them for 30 min. before frying, because a frying time of 5 min. was not adequate for complete protein denaturation. Time and temperature relationships of cooking were also important factors in texture development of wieners

Table 1 Effect of ingredients on the texture of meat balls.

Ingredients	Formulae 1	2	3	4	5
			%		
Brewers' yeast	20.0	20.0	20.0	20.0	20.0
Soy protein isolate(1)	10.0	—	—	—	—
Soy protein isolate(2)	—	10.0	—	—	—
Soy protein concentrate	—	—	10.0	—	—
Cheese whey (dried)	—	—	—	15.0	—
Wheat flour	—	—	—	—	15.0
Vegetable fat	20.0	20.0	20.0	20.0	20.0
NaCl	1.0	1.0	1.0	1.0	1.0
$Ca(OH)_2$	05	0.5	0.5	0.5	0.5
Water	48.5	48.5	48.5	43.5	43.5
Texture	Meaty	Meaty	Gummy	Gummy	Starchy

(1) and (2) different source material.

Table 2 Effect of ingredients on texture and flavor of wieners.

Ingredients	Formulae 1	2	3	4	5
			%		
Hydrolyzed Brewers' yeast	8.0	8.0	8.0	14.5	10.0
Soy protein isolate(1)	—	10.0	—	—	10.0
Soy protein isolate(2)	9.0	—	—	10.0	—
Sodium caseinate	5.0	2.5	—	—	2.5
Skim milk powder	5.0	7.5	10.0	3.5	2.5
Casein	—	—	5.0	—	—
Pea protein concentrate	—	—	10.0	—	5.0
Vegetable fat	15.0	15.0	15.0	15.0	15.0
Wiener seasoning salt	2.5	2.5	2.5	2.5	2.5
$Ca(OH)_2$	0.5	0.5	0.5	0.5	0.5
Liq. smoke	0.3	0.3	0.3	0.3	0.3
Vegetable protein	1.0	—	—	—	—
Water	53.7	53.7	48.7	53.7	51.7
Texture	Meaty	Meaty	Crumbly	Loose	Meaty
Flavor	Meaty	Cereal	Cereal, bitter	Flat	Cereal, bitter

(1) and (2) different source material.

Table 3 Effect of ingredients on texture and flavor of hamburgers

Ingredients	Formulate 1	2	3	4
		%		
Brewers' yeast	8.0	8.0	15.0	15.0
Soy protein isolate(1)	8.0	—	10.0	10.0
Soy protein isolate(2)	—	8.0	—	—
Sodium caseinate	2.0	2.0	—	—
Skim milk powder	2.0	2.0	7.5	5.0
Vegetable fat	20.0	20.0	20.0	20.0
NaCl	2.0	1.5	1.5	1.5
$Ca(OH)_2$	0.5	0.5	0.5	0.5
Hydrolyzed vegetable protein	—	1.0	—	—
Paprika	—	0.2	—	—
Chopped onions	10.0	10.0	10.0	10.0
Water	47.5	46.8	35.5	38.0
Texture	Meaty	Meaty	Hard & rubbery	Starchy & hard
Flavor	Mild, bitter & salty	Meaty	Mild & bitter	Mild & bitter

(1) and (2) different source material.

Table 4 Effect of processing on the texture of wieners.

Time in boiling water min.	Texture	Penetrometer reading*
15	Gummy	240
30	Gummy and loose	226
45	Loose and meaty	212
60	Meaty	192
75	Hard and Meaty	170

* Average of 10 trials.

(Table 4). Less than 60 min. in boiling water did not denature the protein sufficiently to produce a meaty texture. Time in excess of 60 min. caused the wieners to become hard and brittle in texture.

As noted in Table 5, hamburgers could not be subjected to 120°C even for 15 min. since this produced a slightly carmelized flavor although the texture remained starchy. Cooking for only 30 min. at 100°C resulted in a gummy texture, whereas 60 min. produced a satisfactory texture, due to adequate protein denaturation, as well as a meaty flavor.

Various herbs and spices were used in an attempt to incorporate a meaty flavor into the products. However, most spices intensified the bitter flavor of yeast (Table 6), while monosodium glutamate enhanced the characteristic cereal flavor of soy proteins. Some of the major ingredients such as soy protein concentrate and pea protein concentrate also added to the bitter flavor of the products. Since the precursors of a substantial portion of meat flavor are the amino acids and sugars present in raw meat (Hornstein, 1966), yeast and vegetable protein hydrolysates were used to impart meaty flavor in the products. Table 6 shows that Formula 5, which used hydrolyzed vegetable protein as a flavor enhancer, was superior to all other additives in producing a meaty flavor.

Processing conditions also influenced the flavor of the products to a considerable extent. In the case of meat balls, steaming before frying was helpful in removing traces of cereal flavor. Time and temperature of cooking were important factors in producing a meaty flavor in the prepared hamburgers (Table 5).

The proximate chemical composition of the three products is given in Table 7. It will be noted that the composition of all simulated meat products is in excess of 40% protein, which is considerably higher than is found in the majority of comminuted meat products. Further the fat content of these products is lower than similar meat products.

Table 5 Effect of processing on texture and flavor of hamburgers

Cooking temp. °C	Time min.	Flavor	Texture	Penetrometer* reading
120	30	Carmelized	Hard & rubbery	174
120	15	Slightly carmelized	Starchy	180
100	60	Meaty	Meaty	198
100	30	Meaty	Slightly gummy	217

* Average of 14 trials.

Table 6 Effect of ingredients on the flavor of meat balls.

Ingredients	Formulae 1	2	3	4	5
			%		
Brewers' yeast	20.0	20.0	20.0	20.0	20.0
Soy protein isolate(1)	10.0	10.0	10.0	10.0	—
Soy protein isolate(2)	—	—	—	—	10.0
Vegetable fat	20.0	20.0	20.0	20.0	20.0
NaCl	1.0	1.0	1.0	1.0	1.0
$Ca(OH)_2$	0.5	0.5	0.5	0.5	0.5
Black pepper	—	—	0.5	0.2	—
Sugar	—	—	—	0.4	—
Mustard	—	—	0.1	0.1	—
Coriander	0.3	0.3	0.2	0.2	—
Cloves	—	—	0.2	0.1	—
Nutmeg	—	—	0.2	—	—
Chili powder	0.2	0.2	—	—	—
Hydrolyzed vegetable protein	—	1.0	—	—	1.0
Chopped onions	10.0	10.0	10.0	10.0	10.0
Water	38.0	37.0	37.3	37.5	37.5
Flavor	Cereal & bitter	Slighty bitter	Pungent & bitter	Mild & bitter	Meaty

(1) and (2) different source material.

Conclusions

The simulated meat products made from processed yeast and other vegetable ingredients were quite comparable to the respective natural meat products in flavor, texture and palatability. These products can be successfully prepared using only 15% fat without adversely affecting their texture and flavor, to suit those who desire low calorie foods.

Acknowledgement

The authors express appreciation for the financial support received from Canada Department of Agriculture through an Extra Mural Research grant for this investigation.

References

Association of Official Agricultural Chemists. 1965. Official methods of analysis, 10th ed. A.O.A.C., Washington 4, D.C.

Boyer, R. A. 1954. High protein food product and process for its preparation. U.S. Patent No. 2,682,466.

Bremner, J. M. 1960. Determination of nitrogen in soil by Kjeldahl method. J. Agr. Sci. 55: 11.

Dwivedi, B. K. and Gibson, D. L. 1970. Processing of spent brewers' yeast for food uses. Can. Inst. Food Tech. J. 3: 110.

Giddey, Claude. 1965. Artificial edible structures from non animal proteins. Cereal Sci. Today, 10 (9): 516.

Hornstein, I. 1966. Flavor of Red Meats. Symposium on Foods: The Chemistry and Physiology of Flavors, edited by H. W. Schultz. Avi Pub. Co. Inc., Westport, Conn. 1967.

Mojonnier Milk Tester. 1925. Bull. No. 101, Mojonnier Bros. Co., Chicago, U.S.A.

Thulin, W. W., and Kuramoto, S. 1967. 'Bontrae' — A new meat like ingredient for convenience foods. Food Tech. 21: 168.

Received Feb. 4, 1970.

Table 7 Proximate composition of simulated meat products.

Constituents	Meat Balls Formula 5 Table 6	Wieners Formula 1 Table 2	Hamburgers Formula 2 Table 3
Dry matter	41.80	41.50	42.60
Crude protein (N x 6.25)	14.30	18.30	14.50
Ash	1.66	1.93	2.44
Fat	17.20	11.60	19.10
Nitrogen free extract and crude fibre (by difference)	18.64	19.67	16.16